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THE SYSTEM OF *ZETA CANCRI.*

By Miss Agnes M. Clerke.

No feature of recent astronomical progress is more curious than the variety of ways in which the multiplicity of stellar combinations has been brought to light. By the analyzing power of great refractors, especially as used by Mr. Burnham, so many stars already divided have been still further broken up; so many apparently binary unions have been resolved into associations of partial systems, as to suggest that the process ceases only through the merging effects of distance from ourselves on the one hand, and of the mutual proximity of the conjoined suns on the other. Spectroscopic revelations —"epoch-making" in character—of exceedingly close bright satellites to bright stars, circulating with great rapidity in periods of a few days, confirm this suspicion. Without undervaluing the prospects of future optical improvement, it may be asserted that few or none of these can ever be rendered accessible to direct scrutiny. At their greatest elongations, the gap of space between them and their primaries makes, from our point of view, too thin a line for possible discernment.

But the telescope may be baffled by lack of light, as well as by lack of room for observation. For aught it can tell, non-luminous "stars" may, according to the conjecture of Laplace, strew the sidereal tracts as plentifully as luminous ones. The modern armory, however, is stocked with multiform weapons of research. Partial eclipses of bright by opaque masses, alleged by Goodricke above a century ago, in explanation of the variability of *Algol*, have been "spectrographically" demonstrated to occur; and the periodical changes of radial velocity detected by Professor Vogel, in April, 1890, in α *Virginis*, and suspected in *Rigel*, show that these stars also belong virtually to the *Algol* class, although our situation is too far removed from their orbital planes to permit the visibility of occultations.

The gravitational influence of unseen masses may also become sensible through disturbance of tangential movement, whether of the translatory, or of the circulatory kind, but under conditions opposite to those favoring "line-of-sight" determinations. That is to say, the orbit of the disturbing body must be both spacious and highly inclined to the visual ray. Thus, the sinuosities of the track pursued across the sphere by *Procyon* would be imperceptible if greatly foreshortened; and the circumstance that the revolutions of *ζ Cancri* are executed (as it would seem) in a plane differing little from the plane of projection, has alone rendered possible the discovery that a system visually triple is physically quadruple.

The more distant companion at 5″.5 was first noted by TOBIAS MAYER, in 1756, and Father CHRISTIAN MAYER'S observation of it at Mannheim, in 1778, already sufficed to show its retrograde motion. HERSCHEL re-divided the larger star in 1781, and, from 1826 onwards, the trio were kept under pretty constant supervision. They proved, for a ternary combination, unusually mobile, the close couple A B mutually revolving in sixty years, their attendant C circling round their optical centre at the average rate of half a degree annually, but, with singular alternations of delay and acceleration, emphasized, too, by the peculiarity of an approach to the centre at each epoch of arrested or inverted angular change, while retreat from it marked the intervals of swifter revolution. Dr. OTTO STRUVE'S explanation* of these anomalies by the influence of an obscure mass in the immediate vicinity of the star C, has been fully confirmed by the researches of Professor SEELIGER, in 1880 and 1889.† The looped path pursued by C results, there can be no reasonable doubt, from its circulation round an invisible close companion in a period of about eighteen years, at the same time that it describes a much wider ellipse round the pair A B. Since 1826, it has completed three subordinate revolutions, in an orbit of slight eccentricity, the semi-major axis of which subtends an angle of two-tenths of a second. The dark star D, meanwhile, revolves in the same period round the same centre, and at a distance from it, as Professor SEELIGER has shown, little, if at all, greater than that of C. It cannot, then, be much inferior, and may be greatly superior to it in mass. Yet it does not emit light enough to be discerned, even by Mr. BURNHAM, with the aid of the great Lick refractor. This example alone—and several others might be alleged—proves, with tolerable conclusiveness, that the differences in point of intrinsic brightness between the components of multiple stellar systems does not depend solely upon the swifter cooling of the smaller bodies.

The system of *ζ Cancri*, as we now know it, consists of four masses, closely associated, two and two, together; and it has been demonstrated by Professor SEELIGER that, in combinations of this type, KEPLER'S law of equal areas holds good for the elliptic movement of the centre of gravity of one pair round the centre of gravity of the other. Thus understood, it is obeyed, within the limits of observational error, by the stars in question. Their individual perturbations, however, constitute a problem in celestial dynamics which, in the actual state of science, can receive only an approximate solution. Their gyrations are, nevertheless, for the present, sufficiently well represented by nearly circular tracks lying respectively in planes deviating little from the plane of projection. Should the larger mutual orbit of the circling pairs prove eventually to be similarly-shaped and situated, then the *annus magnus* of the system is about 720 years; and all its movements, traced out before our eyes with insignificant foreshortening, are directed so as to favor to the utmost telescopic, but to preclude spectroscopic, determinations. But the record of observation must be greatly lengthened before the orbit of C round A B can possibly be computed.

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* *Comptes Rendus*, t. lxxix, p. 1463.

† *Sitzungsberichte*, Wien, Bd. lxxxiii, Abth. 2, p. 1018; *Denkschriften*, Munich, Bd. xvii, Abth. 1.

The components of *ζ Cancri* usually show a yellow color; but DEMBOWSKI found them all white, in 1855–57, and noticed, in 1864–65, an obvious change in C to yellowish or olive*. Their magnitudes, photometrically measured at Harvard College as respectively 5.6, 6.3, and 6.0, also perhaps fluctuate slightly, but not so as to disturb the *order* of their brightness. The star A always outshines both B and C; while C, to a trifling extent, surpasses B. The proportion of their masses may, however, differ widely from the proportion of their light. SEELIGER finds that the best agreement with observation is obtained by ascribing to C a mass 2.37 times the combined masses of A and B; but until its period and mean distance have been computed, nothing can really be known on the point.

Should the distance of the system from the earth prove measurable, absolute will be substituted for relative values of mass; but the prospect in this direction is not very encouraging. The "hypothetical parallax" of the couple A B, on MÄDLER'S principle of assuming the two together to possess the same attractive power with our sun, is about five-hundredths of a second, corresponding to a light journey of nearly sixty years; and, since they are likely to be more massive, they are also likely to be more remote. Mass varies in the triplicate ratio of distance; an eight-fold mass implies a double distance, and so on. A small, if not wholly evanescent parallax is also indicated by the secular proper motion of 15″.2, common to the three stars. They appear to be of great intrinsic brilliancy. If of the solar mean density, the stars A B must shine with nine times the solar lustre. This is, indeed, only what we should expect from the quality of their light; but it is a matter for surprise that all the stars yet known to be attended by obscure satellites show Sirian spectra, and stand accordingly themselves at the very summit of luminous intensity.

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* *Astr. Nach.*, No. 1574.

NOTICES FROM THE LICK OBSERVATORY.

PREPARED BY MEMBERS OF THE STAFF.

SKETCH OF THE LIFE OF PROFESSOR ELIAS LOOMIS—BORN 1811; DIED 1889—[BY PROFESSOR H. A. NEWTON].

Professor NEWTON, of Yale College, has published, in an octavo pamphlet of forty-four pages (with a lifelike portrait on steel), a sketch of the life of Professor LOOMIS, who was his colleague and friend for many years.* Professor LOOMIS' life nearly covers the period of the rise of American science, and his solid contributions to many branches of thought are set forth in a most fitting and sympathetic light. The subjects of Terrestrial Magnetism, of Astronomy, of Meteorology, engaged his serious labors for a period of more than fifty years. A list of 164 separate memoirs from his hand is given. Of one of these, Professor NEWTON—a conscientious judge—says that its method is at the foundation of "the new meteorology," and that this paper must be regarded as "the most important in the history of that science." Many of his other works are of capital importance also. At his death he bequeathed the sum of $300,000 from his private fortune to the Observatory of Yale College as an endowment fund, thus assuring the future of an institution for which he had already done much. Professor LOOMIS was one of the group of men who were the founders of American science, and his high claims to the gratitude and respect of his countrymen are established by his biographer. His name is most generally known through the admirable series of text-books which he printed from time to time, and which brought him a large fortune. His chief interest was always "in abstract science without any regard to its practical applications," and his life is one long record of a steady following of

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* This memoir has lately been reprinted in the *Sidereal Messenger* for June, 1890.